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CALIFORNIA GEOLOGICAL SURVEY

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DATE: June 27, 2007

SUBJECT: Summary Report of the Pilot Project for a Roads Assessment Methodology for the Jackson Demonstration State Forest

INTRODUCTION

In June 2006 the California Geological Survey (CGS) entered into Interagency Agreement Number 9CA54787 with the California Department of Forestry and Fire Protection (CAL FIRE) to conduct a pilot project for a roads assessment methodology to be used at the Jackson Demonstration State Forest (JDSF). The approximately 50,000-acre JDSF is located in the California Coast Ranges along State Highway 20 in western Mendocino County, California, between the communities of Willits and Fort Bragg (Figure 1).

This pilot project was designed to aid in the development, evaluation, and testing of useful and appropriate road inventory protocols that can be used as part of JDSF's Road Management Plan which is part of the overall JDSF Management Plan. The methodology and associated Geographic Information System (GIS) database developed by CGS for the California State Parks (CSP) formed the starting point for this pilot. This memorandum and the Geographic Information System (GIS) files present the results of this pilot project.

OBJECTIVE

The objective of this pilot project is to identify and test a system for collecting and managing data of potential sediment sources and possible public safety concerns that can be utilized by JDSF as a component of their Road Management Plan. This pilot project tests field data collection and data management methods and procedures that may be used for the long-term monitoring and implementation of the JDSF Road Management Plan.

The GIS and associated databases provide a means of managing road condition information, tracking activities and changes over time, and integrating road information with other resource data within JDSF. This allows the information to be integrated into both short and long term road condition monitoring, and to be combined with other resource information for assessment of multivariate conditions such as that needed for cumulative effects assessments. The GIS and associated databases provide a map interface to view and manage the data for long term planning and management at JDSF.

SCOPE OF WORK

The scope of work for the pilot project listed the following five tasks:

1. Meet with JDSF staff to modify established road assessment and GIS procedures to meet JDSF interests. The starting methodology shall be that used for surveys on CSP properties.
2. Modify forms and databases accordingly.
3. Identify a study area.
4. Conduct a road assessment.
5. Prepare this report and Geographic Information System (GIS) database that ranks road segments and watercourse crossings, and provides mitigation recommendations for the pilot area. This task integrates modifications to procedures and recommendations suggested by JDSF staff.

The schedule for completing these tasks was accomplished with the following milestone dates.

July 25, 2006: Met with JDSF staff members, Fay Yee, Sebastian Roberts, Marc Jameson, Robert Horvat, and others to review existing road assessment forms and database and to discuss the location of pilot project. JDSF staff identified the following needs that the existing approach did not satisfy: 1) data on landings was needed, and 2) collected data should be linearly referenced and calibrated to a GIS route that JDSF had previously developed.

September 18-22, 2006: Began pilot project fieldwork with modifications as suggested by JDSF. Developed a revised location log sheet to record distances for linear referencing, and to record miscellaneous “events” related to erosion and infrastructure.

October 16-20, 2006: Conducted additional fieldwork.

December 18, 2006: Delivered draft GIS database to JDSF staff for review.

January 30, 2007: Held interim meeting with JDSF Staff members, Marc Jameson, Sebastian Roberts, and Robert Horvat to discuss procedures and progress. Demonstrated the GIS, database, and example products from the data such as maps, graphics, and charts. Presented a data flow sheet that illustrated how data was collected, how data can be processed through the GIS interface in various ways, and how data can be used to support other general forest management activities. Illustrated how field photography and site-specific reports can be dynamically linked to the GIS to document, support, and augment the road assessment.

April 20, 2007: Completed fieldwork and met with JDSF staff Sebastian Roberts and Robert Horvat in the field to demonstrate data collection procedures.

PILOT PROJECT DESCRIPTION

This project was developed utilizing road assessment methods and data tables originally prepared by CGS for the CSP. The methods were adjusted to be compatible with JDSF's existing GIS and the elements of the JDSF draft road management plan. Key elements of the JDSF draft road management plan are: 1) road network and watercourse crossing inventory, 2) road design and construction standards, 3) road use restrictions, 4) road inspection and maintenance program, 5) road abandonment, and 6) schedule for the road management plan.

During the meeting of July 25, 2006, JDSF staff selected for assessment Roads 450, 453, and 454 and associated spurs, located in the Hare Creek watershed in the western portion of JDSF (Figure 1). JDSF staff reported that this road system was built in1970's and is representative of many of their other roads. JDSF provided a GIS based map of the roads to be surveyed and that provided the starting point for the spatial information.

In total, sixteen and one-half miles of road have been assessed as part of the pilot project. A log form was developed to collect distance information necessary for linear referencing, as well as to record the presence and location of ancillary features. Additionally, a separate GIS data table was developed for data regarding landings.

This project consists of four principal efforts: 1) reviewing existing information in the office; 2) collecting and compiling existing GIS data; 3) conducting field-based engineering geologic assessments and developing accompanying recommendations; and 4) developing of the GIS to manage these data.

Information evaluated during the office review includes geologic maps, landslide maps, landslide potential maps, standard and digital aerial photographs, topographic maps and models, hydrographic information, and soil data. Additionally, for this road assessment JDSF provided CGS with a 10-meter Digital Elevation Model (DEM) and hydrography layer derived from an existing LIDAR dataset. This LIDAR dataset encompassed a portion of the pilot project area. Specifically, LIDAR coverage extends along Road 450 from 0.66 to 8.88 miles from the eastern origin. The topography for the remaining portion of the pilot area was derived from the 10-DEM generated from the USGS 7-1/2 minute quadrangle map.

The field assessment: 1) identifies potential sediment source areas along road segments, landings, and watercourse crossings, and other smaller-scale features; 2) ranks each potential source as having a high, medium, or low potential for delivering sediment; and 3) provides recommendations for potentially mitigating each site. The rankings are based on professional judgment on the relative potential for sediment to be delivered to a watercourse so that JDSF staff may plan and prioritize road improvement and abandonment projects.

Background data, information, and recommendations from the field assessment are built into a geodatabase consisting of six tables: 1) rds (roads), data regarding road segments; 2) xings (crossings), data regarding watercourse crossings; 3) landings, data regarding landings; 4) pts (points), data for miscellaneous items that are best represented as a point; 5) lines, data for miscellaneous items that are best represented as a line; and 6) calib_pts (calibration points). For this pilot, sites that are less than 100 feet long are mapped as points; those that are longer are mapped as lines.

The GIS database development consisted of: 1) identifying modifications to existing process and procedures to meet JDSF needs; 2) developing the data flow sheet; 3) devising new data tables; and 4) implementing the modifications into the field and GIS processes. A flow chart representing the process from data collection to generation of products is provided as Figure 2.

The information within the data tables are assessable through both ArcMap and Access. The structure of the geodatabase and tables, as well as associated metadata can be accessed using ArcCatalog. The data querying capabilities of Access may be used to summarize the large datasets into themes or “views” relevant to particular interests, however to minimize the potential for incomplete data entry or data transfer, it is recommended to restrict such activities to the GIS environment using ArcMap or ArcCatalog. The GIS can be expanded, revised, and updated as desired to allow it to be used as a platform for systematic long-term road management.

PILOT PROJECT SITE SETTING

JDSF staff report that Roads 450, 453, and 454 were constructed midslope across the Hare Creek watershed in the 1970s. These roads cross numerous Class II and Class III watercourses and are representative of many of the other roads in JDSF. A separate set of ridgetop roads and skid trails higher on the slope interconnect with Road 450.

According to geologic and geomorphic mapping (Short and Spittler, 2002); Roads 450, 453, and 454 are underlain with the Coastal Belt of the Franciscan Formation, a variably indurated and competent rock which is less prone to landsliding than the Central Belt that underlies the eastern portions of JDSF. On a regional scale, that contrast in slope stability and erodibility will likely be reflected in road conditions and will need to be considered during road assessments and subsequent management efforts.

The National Resources Conservation Service (NRCS, 1993) soil map shows that Road 450 crosses two primary soil types: the Vandamme Loam/Vandamme-Caspar series and the Irmulco Tramway Complex. Slope angle and slope position are the primary geographic distinctions between two soil types with the former occurring higher on the slopes. The soils are described as clay loams except the Caspar soil types are reportedly sand loams. Overall site conditions were generally reflective of those regional-scale maps and interpretations.

Based on observations made during the assessment, the texture and hardness of rocks mapped as the Coastal Belt (as exposed in road cuts) varies. Along some ridges, the sandstone (greywacke) is hard and blocky. The excavated material produced from the cuts made apparently durable fill material with a higher angle of repose. The road was in relatively good condition. Along other ridges the cutslopes reveal weaker, fine-grained sandstone that appear to have produced loose sandy material that is not well suited for road fill. The cutslopes along these softer areas of bedrock, deposit sand into ditches and may increase the risk that culverts become plugged. In cases where the sand has washed past plugged culverts it appears to be deliverable to watercourses via the ditch. The roadbed in these areas appears to be very dusty when dry; but soft and prone to rutting when wet.

The soil map identifies Vandamme-Caspar Complex (sandy loam) along the western portion of Road 450. This is consistent with an apparent east to west transition from clay loams to sandier soils that lie along the ridges. These soils are more erodible where disturbed by roads, trails, or concentrated runoff. Unauthorized motorcycle use has more of an impact in this area. Those uphill sediment sources impact Road 450 and should be assessed. The geologic map indicates the presence of "older sand dunes" and "Quaternary marine terrace sediment" in the western portions of JDSF.

FIELDWORK SUMMARY

Presented below is a summary of the data collection methods employed. More detailed explanations of the data are located on the accompanying CD in the data dictionary for the road segment data, and the data dictionary for the watercourse crossings data.

Location Log and Field Map for Linear and Spatial Referencing

A combination of linear and spatial referencing was used to identify specific locations of features along the roads. The survey identified relevant features along the road and a location log was generated as the survey proceeded. For the noted features, the log provides measured distances along the road from specified origins. Location measurements (linear references) from the specified origin were primarily made using the odometer on an ATV. Location measurements shorter than the resolution of the odometer, ~500 feet, were paced. At numerous locations where spatial control was good, calibration points were mapped for the purposes of fixing the measured linear references to locations on the map. Road intersections, prominent watercourse crossings, and conspicuous landings or bends in the road were typically used as control points. The collected information was then transferred to the GIS database.

Watercourse Crossings

Data were collected for each watercourse crossing within the pilot project area. The data collected included such items as type of drainage facility and erosion conditions. Measurements were made with a 25-foot long stadia rod, a tape measure, a folding ruler, and a clinometer. It was noted that many of the crossings were relatively problem-free and shared common characteristics without significant differences. Such crossings were subdivided into groups based on road-width and culvert-diameter. For each group, detailed data was collected for several representative crossings and notes were made on the location log. For crossings that were substantially unique, complex, or significantly problematic; detailed data were recorded on a 2-page field form. All of the collected information was transferred to the GIS database.

Road Segments

The road segment selections were based on significant variations in sediment production and changes in the need for sediment control measures. In the field, the beginning and end points of the road segments were marked on a map. The linear references for beginning and end points were assigned later after the road map was adjusted to the calibration points.

Landings

In the field, the locations of landings were noted on the location log. Smaller or less exposed landings were treated as points and larger landings were treated as lines. Erosion features associated with landings were also noted as encountered. The landings were generally heavily overgrown along the margins, and obvious signs of significant erosion were not noted, therefore it was not practical to fully inspect the margins of each landing. As an additional means, aerial photography dated 1998 and 2005 were reviewed for erosion features. Both field and air-photo based information is stored in the “landings” data table.

Measurements, Origins, and Accuracy of Maps

The overall survey was begun at the east gate across Road 450 near the intersection with Highway 20. The gate is 309 feet, as measured along Road 450 by string box, off the centerline of Highway 20. More detailed notes about the origins used for distances for each road and the quality of the existing mapping are listed below.

ROAD 450

The survey of Road 450 utilized two separate origins. The primary origin was the gate on the eastern end of the road near the intersection with Hwy 20. A secondary origin was established at the intersection of Roads 450 and 512 for temporary purposes. Following the survey, the distances measured from Road 512 were later recalculated relative to the primary origin. The primary origin was later moved 309 feet to the centerline of Hwy 20 for better spatial control. The distance values in the database were then modified relative to the adjusted primary origin.

Fieldwork occurred in three separate one-week surveys. The first week (September 18-22, 2006) of the survey began at the primary origin – the east gate, near the Hwy 20 intersection. The first week's survey proceeded for a distance of 7.75 miles.

For the second week (October 16-20, 2006) of fieldwork, the project area was accessed via Road 512. Road 512 intersects Road 450 at 8.61 miles from the east gate. The survey was resumed at the intersection in two legs.

For the third week (April 16-20, 2007) of the fieldwork, the project area was accessed through Roads 400 and 440. The survey of Road 450 commenced where it was previously left off at mile 10.64 and continued to a landslide deposit that blocks the road at mile 15.0.

ROAD 450B

The JDSF GIS road map identifies this road as a single segment 0.2 mile in length. Field reconnaissance shows that the road is significantly longer with multiple branches.

ROAD 450C

The JDSF GIS road map identifies a road in this area; however, no obvious evidence of the road was found. A skid trail is present in this area but its orientation is different from that of the mapped road.

ROAD 450D

This road was not surveyed due to time limitations. Access constraints were not evaluated.

ROAD 450E

This abandoned spur road extends eastward from a heavily overgrown landing along a ridge. A recognizably constructed roadbed was not found in the heavy brush. Review of available aerial photographs from 1998 and 2005 do not clearly indicate the road. The photos do not show any major erosion issues in the area of the road location. Time constraints limited further investigation.

ROAD 450 (between mile 11 and 12)

Two intersections with unmapped roads were found between mile 11 and 12.

ROAD 453

The northern intersection with Road 450 was used as the origin for distance measurements. The road is relatively well mapped in the preexisting GIS information with the exception of the first 1,000 feet. ATV access was not achievable past the 1.2-mile point where landsliding and dense brush obscure the roadbed. From that point, distances were measured with a survey wheel with an odometer, and where the thick brush required crawling, a string box was used.

ROAD 454

This loop road is relatively well mapped. It was surveyed beginning at the northern intersection with Road 450 and proceed southward and then westward to the southern intersection with Road 450.

FINDINGS

Findings from this pilot project are presented in two categories below. The first category “Findings related to pilot project road assessment methodology” addresses the pilot project road assessment methodology. The second category “General findings for roads 450, 453, 454 and associated spur roads” addresses the condition of the specific roads evaluated during this pilot project; site-specific findings and recommendations for the pilot project road segments, watercourse crossings, and identified erosion-related features are contained in the GIS files.

Findings Related to Pilot Project Road Assessment Methodology

1) Mapping of Road Network

The GIS-based road network supplied by JDSF was compiled from a number of sources of varying accuracy. The roads and landings are well represented in the area of the LIDAR coverage, and the GIS-based road network in the area of LIDAR coverage was accurately represented. LIDAR coverage extends along Road 450 from 0.66 to 8.88 miles from the eastern origin.

The GIS-based road network for the remainder of the pilot project area was less accurately represented, in some cases significantly. This inaccuracy resulted in a significant loss of efficiency during the road assessment due to the necessity to resolve differences in measured versus mapped roads and landings. In these areas, numerous control points were required to match linear references to the existing GIS-based maps.

Improvements to the mapping of the road network would therefore facilitate the full scale road assessment. The use of a LIDAR-based DEM would significantly improve the accuracy of the GIS-based road network and associated features.

Additionally, it was found that the LIDAR based DEM provides a simple means to map road grades and landings. Additionally, roads, areas of significant cuts or fills, and landing perimeters could be mapped directly from the LIDAR based DEM, and checked in the field. Having a LIDAR based DEM for the full-scale road assessment project would greatly speed up the road assessment process, enhance the accuracy of measured values, and reduce the need to rely on estimates or averages collected in the field.

2) Linear Referencing

During this pilot project, linear referencing was used. The use of linear referencing allows the collection of data without relying exclusively on accurate mapping of the road system. Its use provides a finer level of detail of road conditions and recommendations than if the GIS-based road network were solely used.

3) Watercourse Crossing Inventory and the Value of LIDAR

The LIDAR-DEM generated map of watercourses was significantly more accurate and useful than other available mapping (USGS 1:24,000 scale maps and THP maps); although, it was not completely reliable on a fine scale. A DEM with a finer resolution (3 to 5 meter) would likely be more reliable on a fine scale. The LIDAR-DEM generated watercourse map provided a guide to important hydrologic control points along the road network, and assisted in assessing the potential for sediment delivery from the road network at specific locations. Additionally, the LIDAR-DEM hydrography was helpful in more precise mapping of the culvert locations at natural watercourses by providing additional control points. The programs that generate the hydrography from the LIDAR-DEM can also be used to calculate flow magnitudes at culvert locations along the watercourse network to help determine proper culvert sizing.

4) Numbering System for Culverts

The pilot project uses a sequential numbering system for the culverts and watercourse crossings. This can become problematic if additional culverts are installed, or if culverts are removed. It also presents problems with inventorying culvert cross-drains separately from watercourse crossings. A different numbering system based on measured distances from permanent landmarks such as gates or intersections would be preferable for long term tracking and management of the culvert system.

5) Other Process Considerations

The road inventory methodology could be enhanced by incorporating several modifications, including: integrating landscape-level data during the initial office phase of the inventory; using appropriately trained foresters or forestry technicians for certain aspects of the inventory; and using flash photography to inspect culverts.

Many of the landscape-scale geologic or topographic limiting features, such as steep slopes, active landslides, and inner gorges, can be preliminarily mapped in the office to reduce field time. These features could then be field checked and modified as appropriate. Additionally, features not captured during the office exercise could be added when encountered in the field.

With an appropriate quality assurance/quality control process in place, much of the road assessment data, particularly for cross drains and watercourse crossings, could be effectively collected by a Registered Professional Forester (RPF) or a trained forestry technician, with the Certified Engineering Geologist (CEG) called upon to evaluate specific areas.

In cases where it is difficult and time consuming to view directly down a culvert because of slippery slopes, water, and/or dense brush, a digital camera with a flash may be used to photograph the inside culvert conditions and to view the display. These photographs can be easily saved and linked to the GIS.

6) Linking site-specific information with the road inventory

To enhance the utility of the road inventory database, the GIS can be linked to digital photographs, specific reports, maintenance records, or other points of interest. Repeated photography or collected road data could then be used as part of an inspection or monitoring program. General road or crossing treatments, standard best management practices (BMPs), and standard construction drawings could also be linked to the road inventory through the GIS. These linkages would potentially simplify the development of various future environmental documents.

7) Data to Support Road Abandonment or Other Decisions

The rankings and recommendations from the road assessment are a first level indication of whether road maintenance, repair, or abandonment is desirable or needed. The recommended treatments indicate which concerns are easily resolved which are may be more complex and require further investigation. Other managerial, operational, and environmental factors beyond the scope of the specific road assessment, such as planned harvesting operations and critical habitat values, need to be considered along with the road ranking and recommendations generated from the road assessment. The GIS can be used as a central hub as additional criteria are developed and pertinent data is collected.

8) GIS and Database

Because a comprehensive road assessment for the approximately 500 miles of roads in JDSF will be very data extensive; a well-designed data management system is imperative. The geodatabase must match the field methodology, and data collection must conform to the database definitions and specifications. This will require that both field personnel and GIS staff be involved in the data management design process. Although the non-relational geodatabase is functional as-is, a relational geodatabase is would be easier to use and more robust for the larger dataset encompassing the entire JDSF.

A data model or workflow diagram is presented in Figure 2. The model shows three phases of effort: data collection, reclassification and analyses, and product generation.

<u>General Findings for Roads 450, 453, 454 and Associated Spur Roads</u>

Site-specific findings and recommendations for road segments, watercourse crossings, and identified erosion-related features are located in the GIS and can be displayed as data tables, maps, and graphics. Below are generalized findings and recommendations for Roads 450, 453, 454 and associated spur roads in order to show the most significant concerns noted during the assessment.

9) Engineering Properties

The engineering properties of the soil and bedrock along the JDSF roads in the Pilot Project area are variable. Generally, soils higher on the slope and those toward the west appear to be sandier and more prone to erosion. Also, the competence of exposed bedrock varies from ridge to ridge, but a spatial pattern was not evident. In areas of weaker bedrock the roadcuts appear to be chronic sources of sandy sediment.

10) Major Fill Failures

Episodic road/landing fill failures on steep slopes that denude lower slopes are the major road-related sediment source within the pilot project area. Areas denuded by the slides produce significant, continual erosion. The failures do not appear to be related to underlying slope instability but relate mainly to surface ***(?)*** drainage, likely coupled with poor historic practices of fill placement. Some of the failures may have occurred due in part to drainage redirected from other problems spots.

11) Cutslopes

Chronic sloughing of sediment from cutslopes is transported via inside ditches to watercourses. In some areas, cutslope debris threatens to plug culverts and ditches, which may result in uncontrolled flow across the road surface that may erode the fill.

12) Skid Trails

In many areas the skid trails have not been adequately treated for erosion control near their juncture with the roads. Thus, in these locations, chronic erosion is occurring, and the resultant runoff and sediment is being transported into the road and road ditches. Unauthorized motorcycle use increases this erosion along the skid trails.

13) Landings

Some landings have bare surfaces and are in-sloped. Runoff and sediment from these landings contribute to the sediment load in nearby road ditches.

14) Soft Road Surfaces

Soft road surfaces were observed in some locations. These soft road surfaces appear to be the result of less cohesive soils and are susceptible to rilling and rutting. The sediment generated from theses soft road surfaces fills the ditches and plugs the culverts, and apparently has resulted historically in repeated grading of these sections of road.

15) Sheet-Flow Down Road

Where road approaches drop in elevation toward watercourse crossings, sheet flow across the road surface washes fine-grained sediment towards the crossings. The sediments either accumulate in the low spot on road, enter the ditch, or wash across the fill directly above the watercourse without adequate buffering by vegetation.

16) Watercourse Diversion

Watercourse diversion is possible at watercourse crossings where road approaches climb toward the watercourse crossings. This geometry is conducive to watercourse diversion in cases where a culvert backs up due to blockage or inadequate capacity.

17) Skid Trails Adjacent to Watercourses

Some skid trails are located immediately adjacent to watercourses. In some instances the skid trail cuts ravel, slump, and shed sediment into adjacent road ditches, which may become blocked, and excess runoff may spill onto the road, sometimes eroding the fill face. Where a ditch is functional it may deliver unfiltered sediment directly to a watercourse.

RECOMMENDATIONS

Recommendations Related to Pilot Project Road Assessment Methodology

1) Mapping of Road Network

Improvement of the mapping of road network is needed for an efficient road assessment and road management program. In the pilot project the LIDAR based DEM proved to be a very useful tool for developing an accurate road network. Based upon the information gathered during the pilot project, the monitory investment for LIDAR coverage appears to be justifiable due to its reliability and multiple uses for the road survey and hydrology information. A LIDAR- based DEM with a resolution of about 3 to 5 meters would likely be more reliable for fine-scale evaluation than the 10-meter LIDAR-based DEM utilized in part of the pilot project area.

Although the road assessment can be conducted without the benefit of a high quality road network map, the efficiency, accuracy, and cost of the process is hindered. Alternatives for conducting the road assessment without a high-quality road network map include: 1) map road alignments as a part of the road assessment, 2) map the network prior to the assessment, and 3) conduct the assessment first relying on the linear referencing to identify locations and at a later time if desired fit the data to a map.

2) Linear Referencing

Continue to use linear referencing as the method of capturing and recording road related information.

3) Watercourse Crossing Inventory and the Value of LIDAR

Evaluate the feasibility of obtaining LIDAR coverage for JDSF so that an accurate representation of the interaction of the road and watercourse network can be more rigorously assessed. The use of LIDAR-based synthetic hydrography should be considered as a means to help size culverts to evaluate their ability to accommodate 100-year storm runoff.

4) Numbering System for Culverts

Develop a numbering system for watercourse crossings and ditch relief cross-drains that is based on mile-markers, road intersections, or some other fixed feature basis.

5) Other Process Considerations

Integrate landscape-level data, such as geologic and soil units, steep slopes, active landslides, and inner gorges, during the initial office phase of the inventory. This will reduce the field time needed to identify and assess these features.

Develop quality control/quality assurance procedures to ensure that data are collected and catalogued consistently by various personnel and over various times. Consider using appropriately trained foresters or forestry technicians for certain aspects of the inventory.

Use flash photography to inspect and document interior condition of culverts.

6) Linking Site-Specific Information with the Road Inventory

Set up a digital library for site-specific photos, specific reports, and maintenance records that can be linked to from the GIS. Integrate long term photo-monitoring into the documentation process.

7) Data to Support Road Abandonment or Other Decisions

The rankings and recommendations from the road assessment should be coupled with other managerial, operational, and environmental factors beyond the scope of the road assessment (such as planned harvesting operations, critical habitat values, etc.) to develop ultimate recommendations regarding whether road maintenance, repair, or abandonment is desirable or needed. The GIS can be used as a central hub for data collection and analysis as additional criteria are developed and pertinent data is collected.

8) GIS and Database

The existing data management system should be further developed so that it encompasses all aspects of data collection, storage, retrieval, update, and document creation. This should include modules that:

•Support analyses, budgeting, short and long term monitoring,
•Integrate with other data streams and routines (such as habitat surveys),
•Facilitate document development,
•Contain a reference library of studies, standard drawings, photos, etc.,
•Summarize observations and recommendations across a range of scales, and
•Provide a structured framework for the overall road management plan.

Although the non-relational geodatabase is functional as-is, a relational geodatabase would be easier to use and more robust for the data set encompassing the entire JDSF. Because of the large amount of data that a complete road assessment for JDSF would produce, it is recommended that steps be taken to develop the existing database into a relational database system. The advantages include protection of data integrity, reduction of data redundancy, improved simplicity, and prevention of potential editing problems.

General Recommendations for Roads 450, 453, 454 and Associated Spur Roads

9) Engineering Properties

The spatial variation of soil and rock properties along Roads 450, 453, and 454 should be kept in mind when planning management approaches. Important patterns may become evident as other JDSF roads are assessed.

10) Major Fill Failures

To reduce the potential for episodic road/landing fill failures on steep slopes, maintenance operations should use caution when redirecting drainage to down gradient areas. Use of rolling dips, waterbreaks, and critical dips will reduce the potential and magnitude of these occurrences.

11) Cutslopes

Inside ditches should be abandoned in select problem areas to allow the adjacent cut slopes to be stabilized by buttressing. In these areas the road surface can be outsloped or drained by closely spaced waterbreaks or dips.

12) Skid Trails

Erosion control methods should be enhanced on skid trails near where they intersect with the road network or otherwise have a potential of delivering sediment to a watercourse. Actions should be taken to reduce unauthorized use by.

13) Landings

Un-vegetated, in-sloped landings should be treated to limit erosion and to isolate sediment generated by erosion from the roadside ditches.

14) Soft Road Surfaces

Soft road surfaces should be treated to limit sediment generation. Treatment options could include compacting native materials, applying and compacting road aggregate base, installing sub drains, limiting wet season use, and rerouting drainage to vegetated areas.

15) Sheet-Flow Down Road

Measures should be undertaken to reduce the volume of sediment that is carried toward watercourse where road approaches drop in elevation toward watercourse crossings. Vegetation should be allowed to stabilize sediment deposits as feasible. Waterbreaks should be installed to intercept and direct runoff and sediment onto vegetated areas further from the watercourse.

16) Watercourse Diversion

Critical dips should be installed and maintained where road approaches climb toward the watercourse crossings. For larger watercourse crossings, the outlet of the critical dips may require armoring.

17) Skid Trails Adjacent to Watercourses

Erosion controls should be enhanced on skid trails where they intersect roads immediately adjacent to watercourses or otherwise have a potential of delivering sediment to a watercourse .

It was a pleasure to work with JDSF staff on this pilot project. We look forward to assisting you further with implementation of JDSF's Road Management Plan. If you have any questions, please do not hesitate to contact me at 916-324-6426.

Sincerely:

Michael Fuller
Senior Engineering Geologist

Attachments:

Figure 1: Location map
Figure 2: Data model
Compact Disc containing GIS and Road Assessment

cc: Marc Jameson, JDSF
Sebastian Roberts, JDSF
Bill Short, CGS
Tom Spittler, CGS

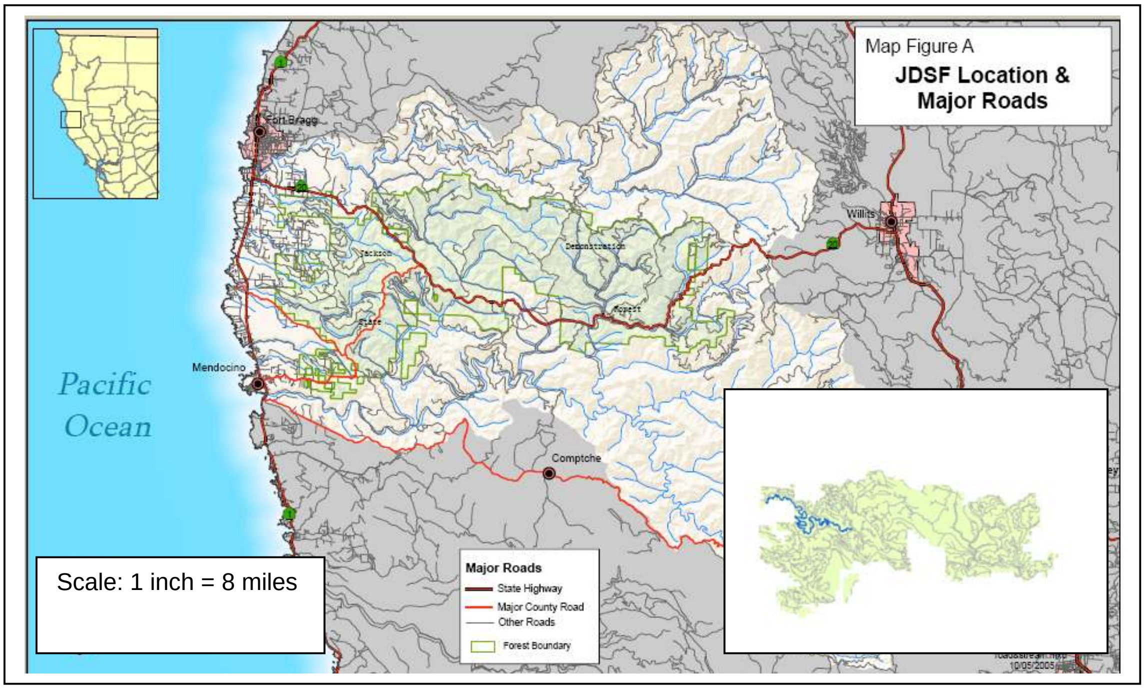

Figure 1: Jackson State Demonstration Forest. Inset map shows roads within JDSF. Blue line represents the roads assessed for the pilot project.

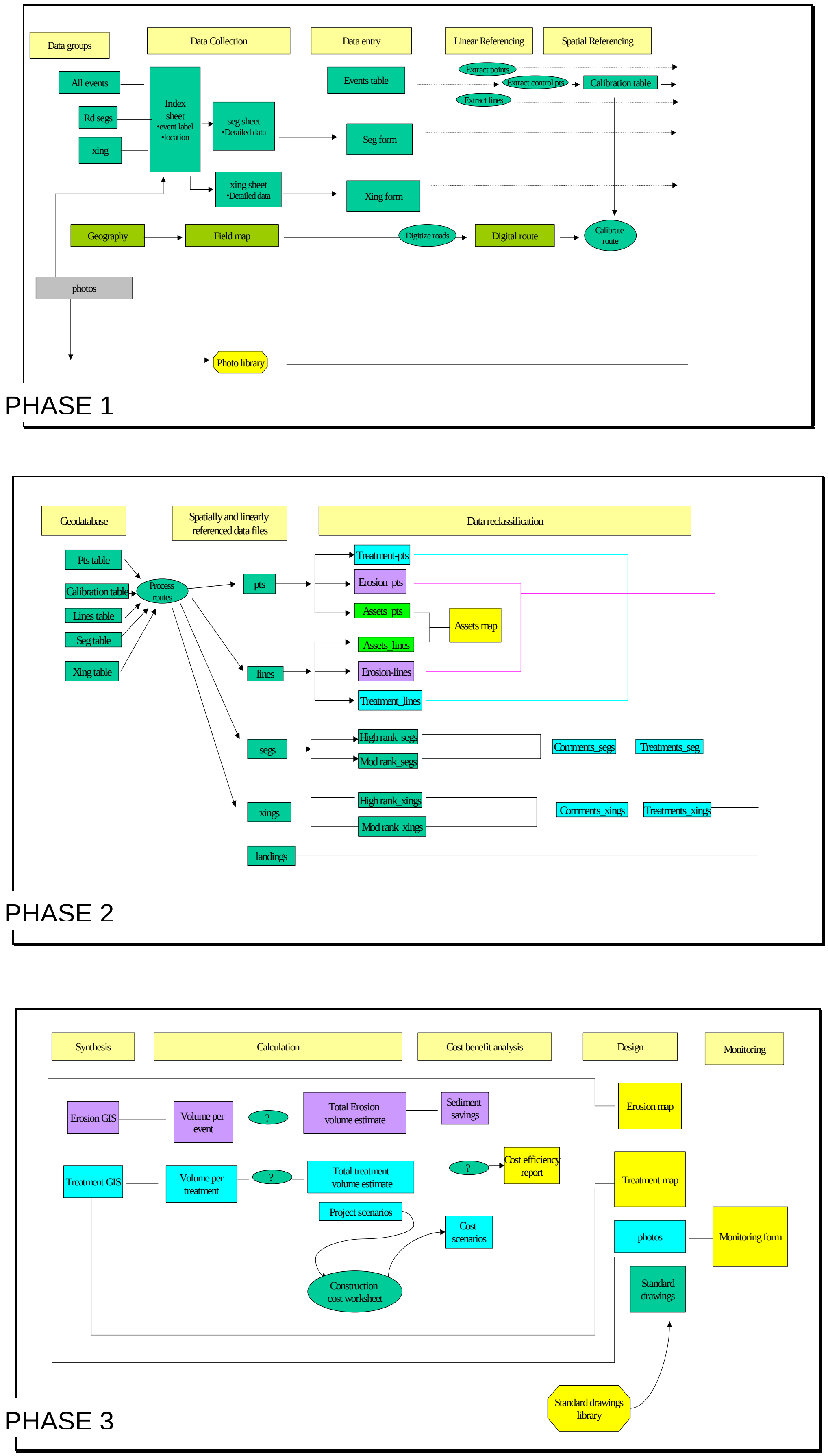

Figure 2: Conceptual data model